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SUMMARIES IN MICRO-BIOLOGY

For some months the Secretary has been seeking to secure for this Journal and its Department of Summaries, a series of papers from biologists dealing with the chief groups of microscopic plants and animals. It has not been the purpose to present a complete survey of any of the groups. The wish has been rather to bring together in one article a statement of the following things:—general biology, the method of finding, the methods of capture and of keeping alive and cultivating in the laboratory; how best to study; the general technic; the most accessible literature; and a brief outline of the classification, with keys for the identification of at least the more representative genera and species of the micro-organisms likely to be found by the beginning students in the United States.

It has been felt that the getting together of such data as this, while not a contribution to science, would be a contribution especially to isolated workers and to teachers and students in the high schools and smaller colleges.

Papers have already appeared treating the aquatic Oligochetes, the Melanconiales, the Rusts, the Black Moulds, the Powdery Mildews, and the Cephaline Gregarines. The following is the seventh paper of the series. It is proposed to have such synopses from time to time until the more common American species of such groups as the following have been covered: The Blue-green Algæ, non-conjugating Green Algæ, Downy Mildews, Yeasts, other Hyphomycetes, Smuts, Rhizopods, Infusoria, Turbellaria, Bryozoa, Water Mites, Entomostraca, etc.—[Editor.]

SYNOPSIS OF THE CONJUGATE ALGÆ —ZYGOPHYCEÆ

BY CHARLES E. BESSEY

A dozen or more years ago the writer prepared a series of papers on these plants, which were published in volumes 21, 22 and 23 of these *Transactions*, and now it seems that time enough has elapsed to warrant another paper dealing with the same group, and including such revisions as are now made necessary because of our better knowledge of their structure, and the structure of the nearly related plants.

The Conjugate Algæ are here held to constitute a distinct phylum of chlorophyll-bearing aquatic plants (algæ) which have diverged from the main evolutionary line from lower to higher algæ. Below them are the Simple Algæ (Protophyceæ), also chlorophyll-bearing, and still lower than these the Slime Algæ (Myxophyceæ).

The phylum Zygomycetæ may be characterized as follows:

Plants typically consisting of unbranched, unattached filaments which easily fragment into short segments, or single cells. Their

cells contain chlorophyll, but this may be hidden by a brownish pigment. Their non-sexual reproduction is by the fragmentation of the filaments into short segments, or single cells, or by the formation of internal spores. Zoospores are unknown. Sexual reproduction is by the union of the protoplasm of pairs of ordinary cells (isogametes).

This phylum seems to have originated from the Simple Algæ (Protophyceæ) through a physiological sluggishness of the cells, which resulted in (1) their feeble attachment to one another and consequent easy and often early fragmentation into few or single cells, (2) the absence of zoospores, and (3) the reduction of the sexual reproduction to a sluggish union of the scarcely modified protoplasm of two vegetative cells. It is thus a group of plants on the "down grade", in which all of its members show more or less of structural degeneration. On account of this sluggishness these plants are sometimes called the "Lazy Algæ".

They may be separated into two classes as follows:

- A. Chlorophyll-green plants with cellulose walls...Class I *Conjugatæ*.
- B. Mostly brownish plants, with silicified walls.....
-Class II *Bacillarioidæ*

CLASS I. CONJUGATAE

Plants microscopic, typically simple, unbranched rows of cells, often separating early into isolated cells; cell-walls composed of cellulose.

Here there are two orders:

- I. Cells in long cylindrical filaments.....Order 1 *Zygnematales*.
- II. Cells mostly solitary by the early fragmentation of the filament, often flattened.....Order 2 *Desmidiæ*.

Order 1. Zygnematales. Pond Scums¹

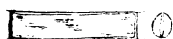
Filaments elongated, unbranched, cylindrical, with thin, cellulose walls; not rooted, and with two growing ends. Floating at the surface of the water of quiet pools, rarely in running water,

¹In the preparation of these keys and brief descriptions, I have made free use of the excellent monograph on "The Green Algæ of North America" by Frank S. Collins. (Tufts College Studies, Vol. II, No. 3). The difficulty of obtaining that work (now nearly out of print) is the only excuse for this summary presentation.

The three families may be separated as follows:

1. Chloroplast single, long, axial.....Family 1 *Mesocarpaceæ*
2. Chloroplasts two, short, axial.....Family 2 *Zygnemataceæ*
3. Chloroplasts 1 to 9, parietal, spiral.....Family 3 *Spirogyraceæ*

FAMILY 1. MESOCARPACEAE



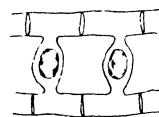
1. *Mougeotia*; showing chloroplasts.

The chloroplast is a single flat plate lying in the axis of the cell, and as wide as, and as long as the cell. The two genera are distinguished by differences in the mode of formation of their resting spores.

- (a) Zygotes formed by the union of cells of different filaments, or cells of the same filaments.....*Mougeotia*.
- (b) Zygotes apparently formed by the union of cells of the same filament, usually regarded as aplanospores.....*Gonatonema*.

MOUGEOTIA

Cells cylindrical, several times as long as wide; zygotes formed between the conjugating cells, by an obvious union of the two protoplasmic units from two different filaments, or contiguous cells of the same filament.

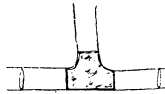


2. *Mougeotia*; zygote touching two cells.

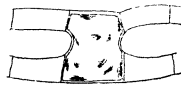
Key to the Species

- A. Conjugation between cells of different filaments ("scalariform").
 - I. Zygote touching two cells.
 1. Filaments 20μ or more in diameter,
 - a. Zygote 50μ or more in diameter,
 - (1) Zygote spherical, in the tube.
 - (a) Filaments about 50μ in diameter....1. *M. crassa*.
 - (b) Filaments about 30μ in diameter.....
 - (2) Zygote angled.....2. *M. macrospora*
 - (2) Zygote less than 50μ in diameter,
 - (1) Zygote wall smooth,
 - (a) Zygote between the filaments.....4. *M. scalaris*.
 - (b) Zygote projecting into the filaments,
 - i. Zygotes greenish.....5. *M. sphaerocarpa*.
 - ii. Zygotes, reddish-brown.....6. *M. minnesotensis*.
 - iii. Zygotes brown.....7. *M. divaricata*.
 - (2) Zygote wall pitted.....8. *M. robusta*

2. Filaments less than 20μ in diameter.
 - a. Zygote 40μ or more in diameter,
 - (1) Zygote wall smooth.....9. *M. delicatula*.
 - (2) Zygote wall verrucose.....10. *M. verrucosa*.
 - (3) Zygote wall with parallel ridges..11. *M. glyptosperma*.
 - b. Zygote less than 40μ in diameter,
 - (1) Zygote wall smooth.....12. *M. parvula*.
 - (2) Zygote wall pitted.....13. *M. nummuloides*.
- II. Zygote touching three cells.....14. *M. tenuis*.



3. *Mougeotia*; zygote touching three cells.



4. *Mougeotia*; zygote touching four cells.

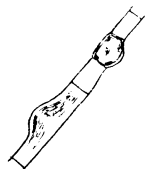


5. *Mougeotia*; end-wise conjugation.

- III. Zygote touching four cells,
 1. Filaments less than 10μ in diameter,
 - a. Filaments $6-8\mu$ in diameter.....15 *M. viridis*.
 - b. Filaments $4-5\mu$ in diameter.....16 *M. elegantula*.
 2. Filaments 10μ or more in diameter,
 - a. Zygote wall pitted.....17. *M. quadrangulata*.
 - b. Zygote wall smooth,
 - (1) Filaments $15-20\mu$ in diameter.....18. *M. capucina*.
 - (2) Filaments $10-14\mu$ in diameter.....19 *M. calcarea*.
- B. Conjugation between contiguous cells of the same filament.....
-20. *M. genuflexa*.

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1. *Mougeotia crassa*.—Cells $50 \times 200-500\mu$: zygote, 65μ .—Florida.
 2. *Mougeotia macrospora*.—Cells $30 \times 180-300\mu$: zygotes, $55-60\mu$.—N. H., Pa.
 3. *Mougeotia laetevirens*.—Cells $22-40 \times 70-300\mu$: zygotes, $40 \times 45-60\mu$.—N. H., Mass.
 4. *Mougeotia scalaris*.—Cells $25-30 \times 50-180\mu$: zygotes, $30-38\mu$.—Mass., N. J.
 5. *Mougeotia sphærocarpa*.—Cells $20-25 \times 60-150\mu$: zygotes, 40μ .—N. J., Pa., Fla., Calif.
 6. *Mougeotia minnesotensis*.—Cells $15-18 \times 60-90\mu$: zygotes, 60μ .—Minn.
 7. *Mougeotia divaricata*.—Cells $20 \times 80-200\mu$: zygotes, 45μ .—Pa.
 8. *Mougeotia robusta*.—Cells $25-32 \times 75-250\mu$: zygotes, $40-50\mu$.—Mass., N. J.
 9. *Mougeotia delicatula*.—Cells $12-14 \times 50-80\mu$: zygotes, $20-30\mu$.—Canada.
 10. *Mougeotia verrucosa*.—Cells $13-14 \times 75-140\mu$: zygotes, $40 \times 20-25\mu$.—Ala.
 11. *Mougeotia glyptosperma*.—Cells $10-15 \times 60-180\mu$: zygotes, $42-49 \times 30-40\mu$.—Mass., Minn., Fla. Usually referred to *Debarya*.

12. *Mougeotia parvula*.—Cells 6-10 x 30-120 μ : zygotes, 8-24 μ .—"Pools north, south, and west".
13. *Mougeotia nummuloides*.—Cells 8-10 x 40-120 μ : zygotes, 17-23 μ .—Me., Mass., N. J.
14. *Mougeotia tenuis*.—Cells 10-13 x 80-200 μ : zygotes ?—Pa., Fla., N. J.
15. *Mougeotia viridis*.—Cells 6-8 x 24-80 μ : zygotes ?—N. J., Fla.
16. *Mougeotia elegantula*.—Cells 4-5 x 60-150 μ : zygotes, 20-40 x 12-14 μ .—West Indies.
17. *Mougeotia quadrangulata*.—Cells 8-12 x 50-140 μ : zygotes, ?—Mass., N. J., S. Car.
18. *Mougeotia capucina*.—Cells 15-20 x 90-280 μ : zygotes, ?—Mass., N. J.
19. *Mougeotia calcarea*.—Cells 10-14 x 40-280 μ : zygotes, 21-50 μ .—Greenland.
20. *Mougeotia genuflexa*.—Cells 25-33 x 50-160 μ : zygotes, ?—N. Y., Mass., Me., N. J.



6. *Gonatonema*; endwise conjugation (?).

GONATONEMA

Cells cylindrical, several times as long as wide: zygotes apparently formed by the endwise union of protoplasmic units of the same filament, usually regarded as aplanospores. We have but one species.

1. *Gonatonema ventricosum*.—Cells 5-7 x 30-110 μ : zygotes, 22-29 x 13-16 μ .—Pa., Calif.

FAMILY 2. ZYGNEMATACEAE

The chloroplasts are two short flat somewhat stellate plates more or less unconnected, and lying in the axis of the cell.

There is but one genus.

ZYGNEMA

Cells cylindrical not much longer than wide: zygotes formed by the union of the protoplasmic units of cells of two different filaments (scalariform), or by the endwise union of the protoplasmic units of cells of the same filament.



7. *Zygnema*; scalariform conjugation.

Key to the Species

- A. Conjugation between cells of different filaments (scalariform).
 - I. Zygotes formed in the tube between the conjugating cells.
 1. Filaments 30 μ or more in diameter; zygotes brownish.....1. *Z. pectinatum*.
 2. Filaments 15-25 μ in diameter,
 - a. Zygotes bluish.....2. *Z. cyanospermum*.
 - b. Zygotes greenish or brownish.....3. *Z. ericetorum*.

- II. Zygotes formed in one of the conjugating cells,
 1. Filaments less than 25μ in diameter.....4. *Z. leiospermum*.
 2. Filaments 25μ or more in diameter,
 a. Zygotes smooth,
 (1) Zygotes bluish in color.....5. *Z. chalybeospermum*.
 (2) Zygotes brownish in color.....6. *Z. insigne*.
 b. Zygotes punctate or pitted,
 (1) Zygotes globose.....7. *Z. cruciatum*.
 (2) Zygotes ovoid.....8. *Z. stellinum*.
- B. Conjugation also between contiguous cells of the same filament.
- I. Filaments about 20μ in diameter. 4. *Z. leiospermum*.
- II. Filaments 30μ or more in diameter,
 1. Zygotes globose, smooth.....6 *Z. insigne*.
 2. Zygotes ovoid, pitted.....8. *Z. stellinum*.



8. *Zygnema*; end-
wise conjugation (?).

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1. *Zygnema pectinatum*.—Cells $30-37 \times 30-110\mu$: zygotes, about 50μ .—Mass., N. J.
 2. *Zygnema cyanospermum*.—Cells $20 \times 40-180\mu$: zygotes, $34-40\mu$.—Greenland.
 3. *Zygnema ericetorum*.—Cells $15-25 \times 15-100\mu$: zygotes, $20-25\mu$.—Me., Mass., Fla.
 4. *Zygnema leiospermum*.—Cells $20-22 \times 20-22\mu$: zygotes, $23-30\mu$.—Greenland, Mass.
 5. *Zygnema chalybeospermum*.—Cells $24-27 \times 24-80\mu$: zygotes, about 35μ .—Calif.
 6. *Zygnema insigne*.—Cells $26-30 \times 26-60\mu$: zygotes, $30-32\mu$.—Mass., N. J., Calif.
 7. *Zygnema cruciatum*.—Cells $35-54 \times 35-54\mu$: zygotes, about 40μ .—Mass., N. J.
 8. *Zygnema stellinum*.—Cells $25-36 \times 25-100\mu$: zygotes, $35-48 \times 30-35\mu$.—Greenland, Mass., Conn., N. J.

FAMILY 3. SPIROGYRACEAE

The chloroplasts are 1 to 9 narrow ribbon-shaped bands, which are spirally arranged in the parietal portion of the cell.

There is put one genus:

SPIROGYRA

With the characters of the family,

Key to the Species

- A. Conjugation by the direct union of two cells, without the formation of a tube.....I. *S. stictica*.

- B. Conjugation by a tube from the male cell only; zygote punctate.....
2. *S. punctata*.



9. *Spirogyra*; tube-less conjugation.



10. *Spirogyra*; with tube from male cell.



11. *Spirogyra*; with tube from both cells.

- C. Conjugation by a tube from each cell,

I. Cross walls plane,

i. Chloroplast 1 in each cell,

a. Zygogonia not swollen,

(1) Filaments 20-36 μ in diameter.....3. *S. longata*.

(2) Filaments less than 30 μ in diameter,

(a) Zygotes about 30 μ in diameter....4. *S. juergensii*.

(b) Zygotes about 20 μ in diameter,

i. Cells 3-5 times as long as wide.5. *S. communis*.

ii. Cells little if any longer than broad.....

.....6. *S. subsalsa*.

(3) Filaments 30 μ or more in diameter,

(a) Conjugation scalariform.....7. *S. porticalis*.

(b) Conjugation endwise between cells of the same filament.....8. *S. condensata*.

b. Zygogonia swollen.

(1) Filaments 27-30 μ in diameter.....9. *S. affinis*.

(2) Filaments less than 30 μ in diameter,

(a) Zygotes about 30 μ in diameter,

i. Zygogonia much swollen...10. *S. catenæformis*.

ii. Zygogonia but little swollen...11. *S. gracilis*.

(b) Zygotes less than 30 μ in diameter,

i. Conjugation scalariform....12. *S. flavescens*.

ii. Conjugation not scalariform; apparently between cells of the same filament....

.....13. *S. mirabilis*.



12. *Spirogyra*; with 2 chloroplasts.

(3) Filaments 30 μ or more in diameter,

(a) Zygotes ovoid or ellipsoid.....14. *S. varians*.

(b) Zygotes variable, from globular to ellipsoid, oblong, pyriform and reniform...15. *S. lutetiana*.

2. Chloroplasts 2 (rarely 3) in each cell,

a. Filaments 43-50 μ in diameter.....16. *S. dubia*.

b. Filaments 34-40 μ in diameter.....17. *S. decimina*.

3. Chloroplasts 3-4 in each cell,
 - a. Zygonia not swollen,
 - (1) Filaments about 100μ in diameter,
 - (a) Vegetative cells swollen.....18. *S. jugalis*.
 - (b) Vegetative cells not swollen....19. *S. setiformis*.
 - (2) Filaments about 75μ in diameter.....20. *S. parvispora*.
 - b. Zygonia swollen,
 - (1) Filaments $50-65\mu$ in diameter.....21. *S. ternata*.
 - (2) Filaments 36μ in diameter.....22. *S. fluviatilis*.

4. Chloroplasts 5-10 in each cell,

- a. Zygonia not swollen,
 - (1) Filaments less than 100μ in diameter,
 - (a) Chloroplasts usually 5.....23. *S. nitida*.
 - (b) Chloroplasts 7-8, little if at all spirally arranged.....24. *S. orthospira*.
 - (2) Filaments 100μ or more in diameter,
 - (a) Cells not longer than their diameter.....25. *S. maxima*.
 - (b) Cells usually longer than their diameter.....26. *S. crassa*.
- b. Zygonia swollen.....27. *S. bellis*.

13. *Spirogyra*; with 5-10 chloroplasts.



II. Cross walls replicate.

1. Chloroplast 1 in each cell; conjugation scalariform,
 - a. Zygonia little if at all swollen,
 - (1) Filaments $22-28\mu$ in diameter.....28. *S. weberi*.
 - (2) Filaments $32-36\mu$ in diameter.....29. *S. protecta*.
 - b. Zygonia swollen,
 - (1) Filaments less than 20μ in diameter,
 - (a) Cells very small, $9-12\mu$ in diameter.....30. *S. tenuissima*.
 - (b) Cells larger, $15-18\mu$ in diameter.....31. *S. inflata*.
 - (2) Filaments 20μ or more in diameter,
 - (a) Cells very long, 10 to 25 times their diameter.....32. *S. spreciana*.
 - (b) Cells shorter, 3 to 10 times their diameter,
 - i. Zygotes $42-48\mu$ in diameter....33. *S. quadrata*.
 - ii. Zygotes $26-30\mu$ in diameter...34. *S. grevilleana*.
2. Chloroplast 1 in each cell; conjugation endwise between cells of the same filament.....35. *S. groenlandica*.
3. Chloroplasts 2 in each cell.....36. *S. hassallii*.
4. Chloroplasts 3 in each cell.....37. *S. insignis*.

14. *Spirogyra*; with replicate cross walls.



1. *Spirogyra stictica*.—Chloroplasts 3-4, nearly parallel; cells 38-54 x 75-200 μ : zygotes to 60 μ .—Fla., Calif.
2. *Spirogyra punctata*.—Chloroplast 1: cells 24-27 x 140-300 μ : zygotes 36 μ .—N. J.
3. *Spirogyra longata*.—Chloroplast 1: cells 20-36 x 48-360 μ : zygotes 20-35 μ .—Mass., R. I., N. J., Colo.
4. *Spirogyra juergensii*.—Chloroplast 1: cells 24-26 x 60-130 μ : zygotes 30 μ .—Calif.
5. *Spirogyra communis*.—Chloroplast 1: cells 20-25 x 60-125 μ : zygotes 19-23 μ .—Mass., N. J.
6. *Spirogyra subsalsa*.—Chloroplast 1: cells 22-25 x 22-37 μ : zygotes 18-20 μ .—Fla.
7. *Spirogyra porticalis*.—Chloroplast 1: cells 30-48 x 60-275 μ : zygotes to 42 μ .—Mass., N. J., Pa., Iowa, Calif.
8. *Spirogyra condensata*.—Chloroplast 1: cells 48-54 x 48-54 μ : zygotes to 36 μ .—N. Mex.
9. *Spirogyra affinis*.—Chloroplast 1: cells 27-30 x 40-90 μ : zygotes to 30 μ .—Jamaica, Alaska.
10. *Spirogyra catenæformis*.—Chloroplast 1: cells 24-27 x 48-150 μ : zygotes to 30 μ .—Mass., Calif.
11. *Spirogyra gracilis*.—Chloroplast 1: cells 18-21 x 50-100 μ : zygotes 30 μ .—Mass., Mich.
12. *Spirogyra flavescens*.—Chloroplast 1: cells 11-13 x 30-50 μ : zygotes 20 μ .—Fla.
13. *Spirogyra mirabilis*.—Chloroplast 1: cells 24-27 x 100-270 μ : zygotes 24-26 μ .—Me., Wis.
14. *Spirogyra varians*.—Chloroplast 1: cells 33-40 x 66-120 μ : zygotes 33-38 μ .—Me., Mass., N. Y., N. J., Iowa, Wash., Calif.
15. *Spirogyra lutetiana*.—Chloroplast 1: cells 30-36 x 90-250 μ : zygotes 30-43 μ .—Mass., Wash.
16. *Spirogyra dubia*.—Chloroplasts 2 (rarely 3): cells 43-50 x 65-125 μ : zygotes 40 μ .—Mass., Pa.
17. *Spirogyra decimina*.—Chloroplasts 2 (rarely 3): cells 34-40 x 70-160 μ : zygotes 38 x 42-75 μ .—Mass., Pa., Iowa, Jamaica, St. Croix.
18. *Spirogyra jugalis*.—Chloroplasts 3-4: cells 9-100 x 90-150 μ : zygotes 100-110 μ .—Mass.
19. *Spirogyra setiformis*.—Chloroplasts 4: cells 100-110 x 100-110 μ : zygotes 96-100 μ .—Mass., Pa., N. J.
20. *Spirogyra parvispora*.—Chloroplasts 4: cells 75 x 150-300 μ : zygotes 50 μ .—Fla.
21. *Spirogyra ternata*.—Chloroplasts 3: cells 50-65 x 75-130 μ : zygotes 45-66 μ .—Ill., Colo.
22. *Spirogyra fluviatilis*.—Chloroplasts 4: cells 36 x 180-215 μ : zygotes 50-80 μ .—Mass., Pa.

23. *Spirogyra nitida*.—Chloroplasts 5: cells 72-78 x 100-230 μ : zygotes 60-72 μ .
—Mass., Conn., N. J., Iowa, Cuba.
24. *Spirogyra orthospira*.—Chloroplasts 7-8, usually straight and parallel:
cells 60-66 x 120-200 μ : zygotes 72 μ .—Mass., N. Y., Pa., Minn., Dak.
25. *Spirogyra maxima*.—Chloroplasts 6-7: cells 130-140 x 130-140 μ : zygotes
100-115 μ .—Pa., Calif.
26. *Spirogyra crassa*.—Chloroplasts 4-10: cells 150-160 x 150-320 μ : zygotes
140-150 μ .—Mass., Pa., N. J., Iowa.
27. *Spirogyra bellis*.—Chloroplasts 5-6: cells 65-80 x 100-240 μ : zygotes 84-90 μ .
—Mass., N. J., Pa.
28. *Spirogyra weberi*.—Chloroplast 1: cells 22-28 x 130-450 μ : zygote 26-30 μ .
—Mass., N. Y., N. J., Pa.
29. *Spirogyra protecta*.—Chloroplast 1: cells 32-36 x 120-430 μ : zygotes 40-42 μ .
—Mass., Conn., N. J., Mich.
30. *Spirogyra tenuissima*.—Chloroplast 1: cells 9-12 x 36-144 μ : zygotes 30 μ .
—Mass., R. I.
31. *Spirogyra inflata*.—Chloroplast 1: cells 15-18 x 45-144 μ : zygotes 30-36 μ .
—Mass., Conn., N. J.
32. *Spirogyra spreeciana*.—Chloroplast 1: cells 18-21 x 180-500 μ : zygotes to
36 μ .—Mass., Wash., Calif.
33. *Spirogyra quadrata*.—Chloroplast 1: cells 24-27 x 75-240 μ : zygotes 42-48 μ .
—Mass., N. Y., Pa.
34. *Spirogyra grevilleana*.—Chloroplast 1 or 2: cells 28-33 x 85-330 μ : zygotes
30-36 μ .—Mass., N. Y., Ia.
35. *Spirogyra groenlandica*.—Chloroplast 1: cells 18-23 x 320-650 μ : zygotes
34-38 x 100-130 μ .—Greenland, Mass.
36. *Spirogyra hassallii*.—Chloroplasts 2: cells 30-35 x 120-280 μ : zygotes 42-
48 μ .—Mass., Iowa.
37. *Spirogyra insignis*.—Chloroplasts 3: cells 38-45 x 150-540 μ : zygotes to
48 μ .—N. J., Pa.

Order 2. Desmidiales. Desmids

Filaments rarely elongated, but frequently broken up early into short segments, or still more commonly into individual cells; in some cases cylindrical, but more often flattened. Cell walls composed of cellulose, and jointed in the middle, the two ends separating easily in fission or conjugation.

The three families may be separated as follows:

1. Cells in longer or shorter unbranched filaments.....
.....Family 4. *Desmidiaceæ*.
2. Cells solitary, elongated, little if at all constricted.....
.....Family 5. *Closteriaceæ*.

3. Cells solitary, broad, deeply constricted.....Family 6. *Cosmariaceæ*.

NOTE—In the following treatment of the Desmids free use has been made of an earlier paper of mine on these plants published in Vol. XXII of the *Transactions* (1901). As in that paper no attempt is made in this one to include keys to the very many species.

FAMILY 4. DESMIDIACEAE

Cells in unbranched filaments, from much elongated to shorter than broad, cylindrical to angular or flattened, and from not at all to deeply constricted; filaments naked or enclosed in a hyaline sheath.

Key to the Genera

- I. Filaments naked (without a sheath),
 - a. Cells cylindrical,
 - 1. Chloroplast single, axial.....1. *Gonatozygon*.
 - 2. Chloroplasts three, parietal, spiral.....2. *Genicularia*.
 - b. Cells barrel-shaped.....3. *Gymnozyga*.
 - c. Cells quadrangular, deeply constricted.....4. *Phymatodocis*.
- II. Filaments surrounded by a hyaline sheath,
 - a. Cells not constricted, or very little,
 - 1. Filaments cylindrical.....5. *Hyalotheca*.
 - 2. Filaments 3- to 4-angular.....6. *Desmidium*.
 - b. Cells deeply constricted, filaments flattened,
 - 1. Cells unarmed.....7. *Sphærozosma*.
 - 2. Cells armed with several divergent horns.....8. *Onychonema*.

I. GONATOZYGON

Cells elongated-cylindrical, or truncate-fusiform, attached to one another in an unbranched filament, which has no sheath, not at all constricted in the middle; chloroplast one, axial, undulated.—Small desmids of few species, rarely seen.

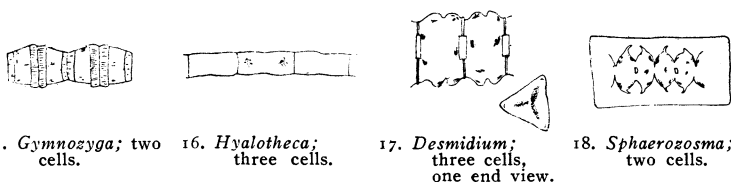
2. GENICULARIA

Cells elongated-cylindrical, attached to one another in an unbranched filament, which has no sheath, not at all constricted in the middle; chloroplasts three, parietal, spiral, sometimes confluent or irregular.—Small desmids of few species, rarely seen.

3. GYMNOZYGA

Cells oblong, barrel-shaped, each with two median hoop-like ridges, attached to one another in an unbranched filament, which

has no sheath, not constricted in the middle; chloroplasts of several axial plates with divergent wings. Small desmids of few species, several of which are common in quiet waters.



15. *Gymnozyga*; two cells.

16. *Hyalotheca*; three cells.

17. *Desmidium*; three cells, one end view.

18. *Sphaerosozma*; two cells.

4. PHYMATODOCIS

Cells oblong, truncate, quadrangular in transection, attached to one another in an unbranched filament, which has no sheath, deeply constricted in the middle; chloroplasts not known. Small desmids, rarely seen.

5. HYALOTHECA

Cells short-cylindrical, attached to one another in an unbranched filament, which is surrounded by an ample, colorless sheath, very slightly (obtusely) constricted in the middle; chloroplasts of several axial plates with divergent wings. Small desmids of few species, several of which are frequent in some portions of this country.

6. DESMIDIUM

Cells oblong, truncate, triangular or quadrangular in cross-section, little or not at all constricted in the middle, attached to one another in an unbranched filament, which is surrounded by a hyaline sheath; chloroplasts of three or four longitudinal plates lying in the angles of the filament. Small desmids, common throughout the country.

7. SPHÆROZOSMA

Cells compressed, deeply constricted in the middle, unarmed, ends rounded or truncate, slightly attached to one another in a lobed, unbranched filament, which is surrounded by a hyaline sheath; chloroplasts quadriradiate.—Small desmids, some species of which are common in ponds and ditches.

8. ONYCHONEMA

Cells compressed, deeply constricted, armed with divergent horns, ends rounded or truncate, slightly attached to one another in a lobed, unbranched filament, which is surrounded by a hyaline sheath; chloroplasts quadriradiate.—Small desmids, rarely seen.

FAMILY 5. CLOSTERIACEAE

Cells solitary, elongated, cylindrical to fusiform; transection circular, not at all, to moderately, constricted; cells sheathless.

Key to the Genera

- I. Cells not constricted, transection circular,
 - a. Cells straight,
 - 1. Chloroplasts of one or more spiral bands.....9. *Entospira*.
 - 2. Chloroplast a single axial plate.....10. *Mesotænium*.
 - 3. Chloroplasts of several axial plates, with divergent wings...
.....11. *Penium*.
 - b. Cells more or less falcate, or semi-lunate.....12. *Closterium*.
- II. Cells straight, moderately constricted, transection circular.
 - a. Chloroplasts axial,
 - 1. Cells short-cylindrical or fusiform, ends rounded, emarginately incised.....13. *Tetmemorus*.
 - 2. Cells long-cylindrical, much elongated, ends truncate or rounded or 3-lobed.....14. *Docidium*.
 - b. Chloroplasts parietal.....15. *Pleurotænium*.

9. ENTOSPIRA

Cells solitary, sometimes aggregated in a gelatinous matrix, straight, oblong-cylindrical or fusiform, not constricted in the middle; transection circular, ends rounded or acuminate; chloroplasts of one or more spiral parietal bands.—In pools, ponds, and in wet mosses.

10. MESOTÆNIUM

Cells solitary, sometimes aggregated in a gelatinous matrix, short-cylindrical, elliptical or ovate, not constricted in the middle; transection circular, ends rounded; chloroplast a single axial plate or ribbon, sometimes divided in the middle—In pools, on wet rocks, walls or damp ground.

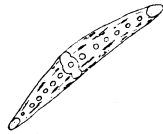
11. PENIUM

Cells solitary, sometimes aggregated in a gelatinous matrix,

straight, cylindrical, or fusiform, not constricted in the middle; transection circular, ends rounded or somewhat truncate; chloroplasts of several axial plates, with divergent wings.—Large desmids, 11 to 80μ in diameter, and 6 to 10 times as long, common in pools and springs.



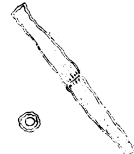
19. *Penium*; one cell.



20. *Closterium*; one cell.



21. *Tetmemorus*; one cell.



22. *Docidium*; two cells and transection.

12. CLOSTERIUM

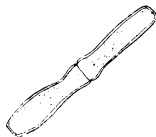
Cells solitary, more or less falcate or lunate, incurved (rarely nearly straight), fusiform or cylindraceous, not constricted in the middle; transection circular, ends acuminate; chloroplasts of several axial plates, with divergent wings.—Medium to large sized desmids, 3 to 110μ in diameter, and from 5 to 20 times as long, common in pools and springs.

13. TETMEMORUS

Cells solitary, straight, cylindrical, or fusiform, moderately constricted in the middle; transection circular, ends rounded, narrowly emarginately incised; chloroplasts axial.—Rather large desmids, common in ponds.

14. DOCIDIUM

Cells solitary, straight, oblong-cylindrical, moderately constricted in the middle, usually long (6 to 30 times their diameter); transection circular, ends truncate, rounded, three-lobed and three-spined; chloroplasts axial, of two to four radiating bands.—Large or medium sized desmids, frequent in ponds.



23. *Pleurotaenium*; two cells.

15. PLEUROTÆNIUM

Cells solitary, straight, cylindrical, more or less constricted in the middle; transection circular, ends truncate; chloroplasts parietal.—Large desmids, some species of which are common in ponds.

FAMILY 6. COSMARIACEAE

Cells solitary, broad, more or less flattened; transection rounded to angular, oblong and elliptical, deeply constricted, the half-cells from entire to many-lobed; cells sheathless.

Key to the Genera

- I. Cells short-cylindrical or orbicular, transection rounded or oblong, half-cells not lobed,
 - a. Unarmed,
 - 1. Solitary,
 - (a) Chloroplasts axial, radiating.....16. *Cosmarium*.
 - (b) Chloroplasts parietal, longitudinally lamini-form.....17. *Pleurotæniopsis*.
 - 2. Joined in gelatinous, branching threads.....18. *Cosmocladium*.
 - b. Each half-cell armed with a spine on each side..19. *Arthrodesmus*.
- II. Cells orbicular, oblong or elliptical, transection flattened or elliptical, half-cells lobed,
 - a. Half-cells with few, usually rounded lobes, and broad sinuses.....20. *Euastrum*.
 - b. Half-cells with many pointed lobes and narrow sinuses.....21. *Micrasterias*.
- III. Cells oblong or orbicular, transection rounded or oblong or angular,
 - a. Armed with spines, chloroplasts parietal, lamini-form.....22. *Xanthidium*.
 - b. Smooth, verrucose or hairy, chloroplasts axial.....23. *Staurostrum*.

16. COSMARIUM

Cells solitary, short-cylindrical or orbicular, smooth, verrucose, or rarely spiny, deeply constricted in the middle; transection sub-oval or oblong, ends rounded or truncate, entire; chloroplasts one or two in each half cell, axial, radiating.—Mostly small desmids of many species, widely distributed and common in mossy ponds.



24. *Cosmarium*; one cell.

17. PLEUROTÆNIOPSIS

Cells solitary, short-cylindrical or rounded, unarmed, deeply constricted in the middle; transection sub-oval or circular, ends rounded or truncate; chloroplasts parietal, longitudinally lamini-form.—Medium to large sized desmids, a few of which may be found in our quiet waters.

18. COSMOCLADIUM

Cells joined in gelatinous, dichotomously branching threads, elliptic-reniform, constricted in the middle; chloroplast one in each half-cell, central.—Small desmids of few species, but one of which has been found (in spring water) in this country.

19. ARTHRODESMUS

Cells solitary, short-cylindrical or orbicular, smooth, with a single spine on each side of each half-cell, deeply constricted in the middle; transection oblong or fusiform-elliptical, ends rounded or truncate, entire, chloroplasts axial, laminated.—Small to very small desmids, not common.

20. EUASTRUM

Cells solitary, oblong or elliptical, with few rounded lobes and broad sinuses, smooth or verrucose, deeply constricted in the middle; transection oblong or elliptical, ends rounded or truncate, usually emarginate or deeply incised; chloroplast one in each half-cell, axial, of longitudinally radiating threads.—Small desmids of many species, widely distributed and quite common.



25. *Euastrum*; one cell.

21. MICRASTERIAS

Cells solitary, orbicular, or oblong-elliptical, deeply constricted in the middle, each half-cell with three to five radiating, pointed lobes, separated by (usually) narrow sinuses, the lobes sometimes again divided; transection fusiform, ends entire, sinuate or incised; chloroplasts axial, laminated.—Large desmids, common in mossy ponds and lakes.



26. *Micrasterias*; one cell.

22. XANTHIDIUM

Cells solitary or geminately connected, orbicular, inflated, armed with spines, deeply constricted in the middle; transection rounded, oblong or angular, ends neither emarginate nor incised; chloroplasts parietal, laminiform.—Medium to small sized desmids, apparently not common.

23. STAUSTRUM

Cells solitary, oblong or orbicular, smooth, verrucose or hairy, deeply constricted in the middle, each half-cell in transection 3-to-6 or more angular, the angles often prolonged into obtuse or acute horn-like processes, ends mostly rounded or truncate; chloroplasts axial.—Small desmids of many species, widely distributed but not abundant.

CLASS II. BACILLARIOIDEAE. DIATOMS

Mostly yellowish-brown plants (by the addition of phyco-xanthin to the chlorophyll) in unbranched filaments, which are circular, angled or flattened in cross section (end view, or "valve" view); or more commonly separated early into isolated individuals (sometimes, however, more or less associated together in gelatinous colonies) which are similarly shaped, or variously twisted or bent; cell wall at first composed of cellulose, early more or less completely silicified; the walls of each cell constitute a closed box ("frustule" of older authors), consisting of two ends ("valves") and two overlapping rings, the "girdle", and in many cases of "interzones" (*zwischenbänder*), which lie between the girdle and the valves; chloroplasts one or two, large and lamelliiform, or numerous, small and granular; asexual reproduction by the division of the cell so as to form two similar cells, or by the escape of the protoplasm from its wall, and the formation of an entirely new wall, or by contraction of the protoplasm of a cell and the formation of a new thick wall (asexual resting spore); sexual reproduction by the union of the protoplasmic contents of two cells, resulting in the formation of one or two new, usually much larger cells.

There are two orders.

- A. Filaments commonly cylindrical, usually fragmented into single cells.....Order 1. *Eupodiscales*.
- B. Filaments flattened, usually fragmented into single cells.....
.....Order 2. *Naviculales*.

Order 1. Eupodiscales. Round Diatoms

Cells in transection cylindrical less commonly polygonal or elliptical, and rarely irregular; ends of cells (valves) marked con-

centrically or radially by dots, areolations, lines or ribs; cells often with spines, processes or horns.

NOTE. In the following treatment of the Diatoms I have made free use of my earlier paper on these plants published in vol. XXI, of these *Transactions* (1900). No attempt is made here to include keys to the very numerous species, for whose recognition good drawings are necessary.

Key to the Families

- I. Cells short box-shaped or discoid, mostly cylindrical in transection, usually without horns or projections,
 - a. Valves not divided into sectors by ribs, sometimes with radial rows of dots, without "eyes" (round or oval, definitely bounded, hyaline areas) or nipples...Family 7. *Coscinodiscaceæ*.
 - b. Valves divided into sectors by ribs, without "eyes" or nipples...Family 8. *Actinodiscaceæ*.
 - c. Valves with radial undulations, or dome-shaped projections, the latter with "eyes", nipples or spines...Family 9. *Eupodiscaceæ*.
- II. Cells two to many times as long as broad, cylindrical, rarely round-elliptical in transection; girdle with numerous interzones...Family 10. *Soleniaceæ*.
- III. Cells box-shaped, about as long as broad (rarely much longer), transection circular to elliptical, with two to many horns much longer than the cell; interzones rarely present...Family 11. *Chatocerotaceæ*.
- IV. Cells box-shaped, shorter than broad or but little longer, transection circular, polygonal or commonly elliptical; valves with two (rarely one) to more poles, each pole with a projection or horn which is shorter than the cell, or when about its length provided with claws; interzones rarely present...Family 12. *Biddulphiaceæ*.
- V. Cells box-shaped, as long as broad or shorter, elliptical, sometimes lunate in transection; valves without horns or projections; rarely with interzones,
 - a. Valves lunate, without transverse septa...Family 13. *Euodiaceæ*.
 - b. Valves not lunate,
 1. Valves with transverse septa, without spines...Family 14. *Anauliaceæ*.
 2. Valves without transverse septa, with a marginal row of spines...Family 15. *Rutilariaceæ*.

FAMILY 7. COSCINODISCACEAE

Cells short, often in filaments, cylindrical, ends of cells (valves) not marked by ribs.

Key to the Genera

- I. Cells forming filaments, girdle-side marked,
 - a. Valves without spines,
 1. Entire valve uniformly marked.....1. *Lysigonium*.
 2. Margin and center of valve differently marked,
 - (a) Marginal portion a narrow ring.....2. *Paralia*.
 - (b) Marginal portion a very broad radially striate ring,
 - (1) Central portion finely punctate.....3. *Hyalodiscus*.
 - (2) Central portion areolated.....4. *Hyalodictya*.
 - b. Each valve with a circle of spines.....5. *Stephanopyxis*.
- II. Cells single, girdle-side not marked,
 - a. Long box-shaped, central portion of valves coarsely areolated..
.....6. *Craspedodiscus*.
 - b. Cells disk-shaped,
 1. Valve markings not consisting of sinuate lines,
 - (a) Valve with distinct central and marginal portions,
without spines.....7. *Cyclotella*.
 - (b) Central and marginal portions of valve grading into one
another,
 - (1) Valve with a circle of spines.....8. *Stephanodiscus*.
 - (2) Valve without spines.....9. *Coscinodiscus*.
 2. Valve markings consisting of sinuate lines.....10. *Liradiscus*.

1. LYSIOGONIUM

Cells cylindrical (or elliptical), closely joined together, not carinate, sometimes transversely furrowed, sometimes superficially denticulate in the plane of the fracture, valves simply punctate.—Species numerous, in fresh and marine waters.



27. *Lysigonium*;
end view.

2. PARALIA

Cells cylindrical, valves furrowed parallel to the edge, valve markings of two kinds, at the center finely punctate, at the edge a circle of areolæ.—Species few, marine and fossil.

3. HYALODISCUS

Cells solitary, geminate or several, valves orbicular, with radiating lines, and with a distinct central smooth umbilicus.—Species few, marine and fossil.

4. HYALODICTYA

Like the preceding, but with the umbilicus closely aerolate.—Species one, in fresh waters.

5. STEPHANOPYXIS

Cells cylindrical or discoid (occasionally elliptical in transection), mostly united in chains, valves tumid convex, hexagonally alveolate, spines usually coronal, sometimes wanting.—Species many, marine and fossil.

6. CRASPEDODISCUS

Cells solitary, long box-shaped, valves diversely areolate, central portion sharply defined from the surrounding border by a spiny line.—Species few, marine and fossil.

28. *Stephanopyxis*;
side view.29. *Cyclotella*; end
and side.30. *Stephanodiscus*;
end and side.31. *Coscinodiscus*;
end view.

7. CYCLOTELLA

Cells mostly single or in twos, short cylindrical, discoid, valves saucer-shaped, diversely marked, central portion inflated, smooth or granulate, surrounded by a circular border marked by fine radiating lines.—Species numerous, mostly in fresh waters.

8. STEPHANODISCUS

Cells single, short cylindrical, discoid, valves circular, slightly convex, not hexagonally areolate, radially granulate with hyaline spaces between the radii, center hyaline or granulate, edge with a simple crown of spines.—Species many, mostly in fresh waters, some fossil.

9. COSCINODISCUS

Cells single, discoid, valves circular, rarely elliptical or rhomboid, flat or centrally depressed, sometimes undulate or plicate, often with a central hyaline circular or irregular area, which may contain an areolate rosette; markings areolate or granulate, margin narrow or broad, mostly with marginal spines.—Species very many, marine and fossil.

10. LIRADISCUS

Cells single, discoid, with a narrow girdle band, valves circular to elliptical, somewhat convex, flattened towards the edge, surface sinuate-reticulate, more or less rough, sometimes with small spines, no central area, margin narrow and hyaline, or broad and radially lined.—Species few, marine fossil.

FAMILY 8. ACTINODISCACEAE

Cells single, short, cylindrical, the valves divided into sectors by ribs, without “eyes”.

Key to the Genera

- I. Ribs or sectors without claws,
 - a. No sharp separation of central and marginal portions,
 - 1. Radial ribs not transversely connected.....1. *Stictodiscus*.
 - 2. Radial ribs connected by transverse lines or rows of granules.....2. *Hemiptychus*.
 - b. Center areolated and surrounded by a hollow, radially chambered border.....3. *Planktoniella*.
- II. Ribs or sectors with claws,
 - a. Valve radially undulate, the alternate sectors dissimilar.....
 -4. *Actinoptychus*.
 - b. Valve not undulate,
 - 1. Rays all alike.....5. *Asterolampra*.
 - 2. One of the rays dissimilar.....6. *Asteromphalus*.

1. STICTODISCUS

Cells single, discoid, valves circular or angled, more or less convex (often unequal), with radial ribs usually **not reaching to** the center, central area usually granulate.—Species many, mostly marine and fossil.

2. HEMIPTYCHUS

Cells single, discoid, valves circular, with numerous stout radiating ribs (often alternately longer and shorter), which are connected by transverse lines or rows of granules, center hyaline.—Species few, marine and fossil.

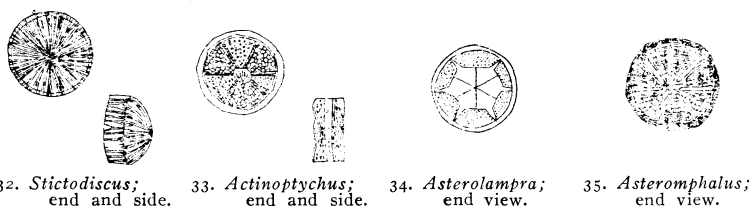
3. PLANKTONIELLA

Cells single, discoid, flat; valves circular, consisting of a sharply defined, slightly areolated center, surrounded by a broad, hyaline,

hollow, radially chambered and ribbed border.—Species one, marine.

4. ACTINOPTYCHUS

Cells single, discoid, valves circular to hexagonal, with radial more or less dissimilar undulations, the surface mostly hexagonally areolate; sectors provided with marginal claws, umbilicus central, often hyaline and mostly stellate.—Species many, marine and fossil.



32. *Stictodiscus*;
end and side.

33. *Actinoptychus*;
end and side.

34. *Asterolampra*;
end view.

35. *Asteromphalus*;
end view.

5. ASTEROLAMPRA

Cells single, discoid, flat; valves circular or obtusely angled, with similar hyaline, radial rays, all reaching the margin and there provided with marginal claws; center sometimes areolate, margins always areolate, with a middle non-areolated band between the marginal band and the center.—Species many, marine and fossil.

6. ASTEROMPHALUS

Cells single, discoid; valves circular or elliptical to oval, with sub-similar, hyaline, radiating rays, all reaching the margin and there provided with marginal claws; center hyaline, crossed by radial zigzag lines, and surrounded by a broad areolated field divided by the rays.—Species many, marine and fossil.

FAMILY 9. EUPODISCACEAE

Cells single, short, cylindrical, the valves with radial undulations, and usually with "eyes".

Key to the Genera

- I. Valves with nipples, no "eyes".....1. *Tripodiscus*.
- II. Valves without nipples, with "eyes",
 - a. "Eyes" sub-marginal, small,
 - 1. Valve surface granulate in radiating lines, one "eye".....
 -2. *Actinocyclus*.

2. Valve surface mostly areolate, one to four "eyes".....
3. *Eupodiscus*.
 b. "Eyes" not marginal, usually large.....4. *Auliscus*.

I. TRIPODISCUS

Cells single, discoid or box-shaped; valves circular (rarely polygonal), bearing one to forty-five sub-marginal nipple-like processes, flat, crateriform, or with an elevated zone; markings granular, in straight or crooked lines.—Species many, marine and fossil.

36. *Tripodiscus*; perspective.37. *Actinocyclus*; end view.38. *Eupodiscus*; end view.39. *Rhizosolenia*; parts of two cells side view.

2. ACTINOCYCLUS

Cells single, discoid, or short box-shaped; valves circular to elliptical or rounded rhomboid, flat (rarely convex), granulate, the granules usually round, and arranged radially; central area usually round; one round, submarginal "eye".—Species many, marine and fossil.

3. EUPODISCUS

Cells single, discoid; valves circular, flat or slightly convex, center often depressed; markings mostly areolate, without a central area, "eyes" one to four, small, near the margin; spines small, few to many, sub-marginal.—Species few, marine and fossil.

4. AULISCUS

Cells single, discoid; valves circular, round to elliptical (rarely bluntly angled), flat, with usually two (rarely one, three or four) truncate, conical processes, each terminating in a large "eye"; central area usually present; markings of the surface variable, granulate, pruinose, to areolate.—Species many, marine and fossil.

FAMILY 10. SOLENIACEAE

Cells long, cylindrical, often in filaments.

We have but one genus.

I. RHIZOSOLENIA

Cells long cylindrical, forming chains; girdle composed of num-

erous scale-like, almost ringed segments; valves unsymmetrical, oblique to the long axis of the cell; cell-wall but little silicified.—Species many, mostly marine, rarely in fresh waters.

FAMILY 11. CHAETOCEROTACEAE

Cells short, cylindrical or somewhat flattened, usually in filaments, with horns longer than the cells.

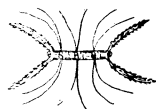
Key to the Genera

- I. Valves circular, with many horns.....1. *Bacteriastrum*.
- II. Valves elliptical, each with two horns.....2. *Chaetoceros*.

I. BACTERIASTRUM

Cells short cylindrical, usually shorter than broad, forming chains, with numerous horns arising at the margins of the valves. Species few, marine.

2. CHAETOCEROS



40. *Chaetoceros*;
one cell, side
view.

Cells short elliptical, shorter or longer than broad, forming chains; valves elliptical, each bearing two long horns, girdle bands but little silicified.—Species many, marine.

FAMILY 12. BIDDULPHIACEAE

Cells short, cylindrical, polygonal, or commonly more or less flattened, often in filaments or loose chains, with horns shorter than the cells.

Key to the Genera

- I. Projections or horns without claws,
 - a. Valves alike,
 - 1. Valves tri- to multipolar, with a projection at each angle,
 - (a) Strongly silicified, without spines or claws...1. *Triceratium*.
 - (b) Weakly silicified, a stout spine at each pole.....2. *Lithodesmium*.
 - 2. Valves bipolar,
 - (a) With spines, strongly silicified,
 - (1) Projections strongly developed.....3. *Biddulphia*.
 - (2) Projections reduced, each bearing a slender spine.....4. *Zygoceros*.
 - (b) Without spines, weakly silicified.....5. *Eucampia*.
 - b. Valves unlike.....6. *Isthmia*.
- II. Projections or horns with terminal claws.....7. *Hemiaulus*.

1. TRICERATIUM

Cells prismatic, box-shaped, free or connected in chains; valves three to many angled, angles more or less prolonged into protuberances, without spines or claws.—Species many, nearly all marine and fossil.

2. LITHODESMIUM

Cells prismatic, box-shaped, united into long chains, valves three angled, each angle with a stout terminal spine; girdle band of many scale-like segments; cell walls incompletely silicified.—Species few, marine and fossil.

3. BIDDULPHIA

Cells box-shaped, elliptical to subcircular in transection, free or connected in chains; valves usually strongly convex, bipolar, each pole with a short protuberance or stout horn, which is rounded or truncate; valves frequently with stout spines.—Species many, marine and fossil.



41. *Biddulphia*; two cells, side view.

4. ZYGOCEROS

Like *Biddulphia*, but with the protuberances of the valves reduced, and bearing a slender spine-like or thread-like horn.—Species few, marine and fossil.

5. EUCAMPIA

Cells short, slightly curved, forming spiral chains; valves elliptical, flat or with two protuberances; girdle band mostly with many cross-lines; cell walls weakly silicified.—Species few, marine and fossil.

6. ISTHMIA

Cells box-shaped, mostly longer than thick, and broad, trapezoidal, free or united into tree-like colonies; valves elliptical, dissimilar, each with a protuberance; girdle band distinct.—Species few, marine and fossil



42. *Isthmia*; several cells, side view, attached.

Cells box-shaped, mostly longer than thick, and broad, trapezoidal, free or united into tree-like colonies; valves elliptical, dissimilar, each with a protuberance; girdle band distinct.—Species few, marine and fossil.

7. HEMIAULUS

Cells mostly box-shaped, transection elliptical to multiangular, with relatively long protuberances, united into chains; valves bi- to multipolar, each pole extended into a short or long horn, terminating in one or more claws.—Species many, marine and fossil.

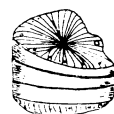
FAMILY 13. EUODIACEAE

Cells short, single, lunate in transection, without transverse septa.

We have but one genus.

1. HEMIDISCUS

Cells box-shaped, single; valves lunate, markings areolate or granulate.—Species few, marine and fossil.



43. *Hemidiscus*;
perspective.

FAMILY 14. ANAULIACEAE

Cells short, single or united into loose chains, lunate in transection, with transverse septa, without spines.

Key to the Genera

- I. Valves with transverse septa appearing in girdle view as straight, incomplete partitions,
 - a. Valves straight.....1. *Anaulus*.
 - b. Valves slightly curved.....2. *Eunotogramma*.
- II. Valves with transverse septa appearing in girdle view as bent, incomplete partitions,
 - a. Incomplete partitions bent-capitate.....3. *Terpsinoe*.
 - b. Incomplete partitions, after bending, elongated parallel to the valve-face.....4. *Porpeia*.

1. ANAULUS

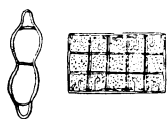
Cells box-shaped, single; valves elliptical, straight, with two transverse septa, which appear as straight, short, incomplete partitions in the girdle view; valve markings punctate.—Species few, marine and fossil.

2. EUNOTGRAMMA

Cells as in *Anaulus*, but the valves slightly curved, and with two to many transverse septa.—Species few, marine and fossil.

3. TERPSINOE

Cells box-shaped, single or united into chains by their angles or valve-faces; valves symmetrical, oblong-elliptical, with lateral undulations, and with two to many transverse septa which in girdle view appear as short, incomplete partitions with thickened curved ends (resembling "notes" of written music).—Species few, fresh-water, marine and fossil.

44. *Terpsinoe*; end and side.

4. PORPEIA

Cells box-shaped, single; valves oblong-elliptical, the middle and ends swollen, with two transverse septa which in girdle view appear as incomplete partitions, which soon bend axially parallel to the valve-face.—Species few, marine and fossil.

FAMILY 15. RUTILARIACEAE

Cells short, united into short chains, not lunate in transection, without transverse septa, with a marginal row of spines.

We have but one genus.

1. RUTILARIA

Cells much broader than long, in valve view oblong-elliptical, united into short chains; valves boat-shaped, somewhat elevated at the ends, surrounded by tooth-like spines.—Species few, marine and fossil.

45. *Rutilaria*; perspective.

Order 2. Naviculales. Flat Diatoms

Cells in transection narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate or irregular; valves marked pinnately or transversely by dots, areolations, lines or ribs; cells without spines, processes or horns.

Key to the Families

- I. Rachis of the valves (i. e., the line between the divergent pinnate markings) evident as a narrow unmarked strip (pseudoraphe), rarely wanting; valve without a slit (raphe),
 - a. Cells usually little shorter than broad or longer, with numerous interzones, mostly united into filaments..... Family 16. *Tabellariaceæ*.

- b. Cells prevailingly much shorter than broad ("rod-shaped" of older authors, the longer axis of the rod representing one of the transverse axes of the cell), often united into filaments,
 - 1. Cells cuneate in girdle view (i. e., valves not parallel), rachis median, interzones present.....Family 17. *Meridionaceæ*.
 - 2. Cells rectangular in girdle view, or if cuneate the rachis not median, interzones present or absent.....Family 18. *Fragilariaceæ*.
- II. Rachis containing an elongated slit (raphe) through the cell wall,
 - a. Rachis commonly median, often more or less lateral, not keeled or when keeled not punctate, interzones present or absent.....Family 19. *Naviculaceæ*.
 - b. Rachis lateral, less often median, punctate-keeled, raphe not plainly visible.....Family 20. *Bacillariaceæ*.
- III. Rachis evident as a narrow, unmarked strip, or keeled; valve with two lateral wing-keels, each enclosing a raphe.....Family 21. *Surirellaceæ*.

FAMILY 16. TABELLARIACEAE

Cells usually little shorter than broad, or longer, mostly in filaments: rachis of valve a narrow, unmarked strip, without a slit.

Key to the Genera

- I. Transverse ribs of the valves, when present, not extending into the cell cavity,
 - a. Valves with a few prominent transverse ribs.....1. *Tetracyclus*.
 - b. Valves transversely striate only,
 - 1. Interzones two to many, septa not undulate,
 - (a) Valves coarsely striate, pseudoraphe present.....2. *Rhabdonema*.
 - (b) Valves finely striate, pseudoraphe absent.....3. *Striatella*.
 - 2. Interzones two, septa undulate.....4. *Grammatophora*.
- II. Transverse ribs of the valves extending deeply into the cell cavity.....5. *Denticula*.

I. TETRACYCLUS

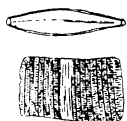
Cells united into flat filaments, shorter or longer than broad, with many interzones, and centrally perforated transverse septa; valves elliptical to oblong, swollen in the middle, without prominent median line, no nodules, and sparingly transverse ribbed.—Species few, fresh-water and fossil.

2. RHABDONEMA

Cells united into flat filaments, shorter or longer than broad, the filaments basally attached by a gelatinous cushion on one corner of the end cell; interzones many, externally cross-marked, their transverse septa variously perforated; valves elliptical or linear-lanceolate, with a pseudoraphe, and transverse-beaded lines and no nodules.—Species few, marine and fossil.

3. STRIATELLA

Cells shorter or longer than broad, united into flat filaments which may partly separate into zigzag chains, basally attached by one corner; interzones few to many, each with an alternately perforated septum; valves linear to elliptical-oblong, more or less swollen centrally and at the ends; without pseudoraphe or nodules; surface transversely striate, not ribbed.—Species many, fresh-water, marine and fossil.



46. *Striatella*; end and side.

4. GRAMMATOPHORA

Cells shorter than broad, united into flat, zigzag chains, basally attached; interzones two, each with an undulate, centrally perforated transverse septum; valves linear to elliptical, sometimes swollen in the middle and sometimes at the ends also, with a faint pseudoraphe, and polar but no central nodules, mostly finely cross striate.—Species many, marine and fossil.



47. *Grammatophora*; two cells, side view.

5. DENTICULA

Cells free, single or united into very short, flat filaments; interzones two, each with a transverse septum with a row of perforations; valves lanceolate, without raphe, with transverse ribs and striae.—Species few, fresh-water, brackish water, and fossil.

FAMILY 17. MERIDIONACEAE

Cells generally much shorter than broad, cuneate in girdle view, often in filaments; rachis of valve a narrow unmarked strip, without a slit.

Key to the Genera

- I. Valves punctate or variously punctate-striate, without transverse ribs,
 - a. Not stalked.....1. *Sceptroneis*.

- b. Cells stalked,
 - 1. Each interzone with a septum only at its broader end.....2. *Licmophora*.
 - 2. Each interzone with a scalariform-fenestrate septum.....3. *Climacosphenia*.
- II. Valves finely transverse-striate and with transverse ribs.....4. *Meridion*.

I. SCEPTRONEIS

Cells free, mostly single, cuneate in valve and girdle view; interzones wanting; valves transversely moniliform-striate, with pseudoraphe which is sometimes very broad; polar nodules sometimes recognizable.—Species few, fresh-water, marine and fossil.

2. LICMOPHORA



48. *Licmophora*;
side (upper)
and end view
(lower).

Cells stalked, single or forming fan-like chains, cuneate in valve and girdle view; interzones two, open at the narrower end and with a septum at the broader end; valves very finely transversely striate, and with a pseudoraphe; nodules wanting.—Species many, marine.

3. CLIMACOSPHEA

Like *Licmophora*, but the interzones with scalariform-fenestrate septa.—Species few, marine and fossil.

4. MERIDION

Cells free, united into fan-shaped or spiral chains, cuneate in valve and girdle view; interzones wanting; valves cuneate, rounded at the ends, with transverse ribs, and fine, transverse, centrally interrupted striae, this interruption forming a pseudoraphe.—Species few, in fresh waters.



49. *Meridion*; end
and side.

FAMILY 18. FRAGILARIACEAE

Cells generally much shorter than broad, generally rectangular in girdle view, often in filaments; rachis of valve a narrow unmarked strip, without a slit.

Key to the Genera

- I. Rachis median,
 - a. Valves with transverse ribs, or if not ribbed, with a central "eye",
 - 1. Without a central "eye".....1. *Odontidium*.
 - 2. With a central "eye".....2. *Plagiogramma*.

- b. Valves without transverse ribs, without a central "eye",
 - i. Ends of valves alike,
 - (a) Cells in filaments, or zigzag chains,
 - (1) Valves flat, without polar nodules.....3. *Fragilaria*.
 - (2) Valves raised at the ends, and often in the middle, with polar nodules.....4. *Dimerogramma*.
 - (b) Cells single, or forming fan-like, stalked clusters.....5. *Synedra*.
 - 2. Ends of valves unequally swollen.....6. *Asterionella*.
- II. Rachis near one margin,
 - a. Ends of valves alike,
 - 1. Pseudoraphe and central nodule evident.....7. *Ceratoneis*.
 - 2. Pseudoraphe and central nodule not evident.....8. *Eunotia*.
 - b. Ends of valves unlike.....9. *Tibiella*.

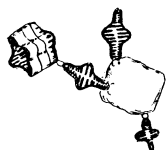
I. ODONTIDIUM

Cells united into short bands or zigzag chains, which are attached at the base, not cuneate, girdle view oblong-rectangular; valves lanceolate to linear with transverse ribs, and fine transverse striæ, the latter interrupted centrally by the indistinct pseudoraphe; no central nodule.—Species few, in fresh waters.

2. PLAGIOGRAMMA

Cells often united into chains, free, not cuneate, girdle view oblong-rectangular; valves linear or elliptical, transversely punctate striate and sometimes ribbed, with a central "eye"; pseudoraphe often present; terminal nodule present.—Species many, marine and fossil.

3. FRAGILARIA



50. *Fragilaria*; several cells, end and side.

Cells united into mostly ribbon-shaped, rarely zigzag, chains, not cuneate, girdle view rectangular, mostly narrowly linear; valves linear-lanceolate or fusiform, flat, transversely striate or with transverse rib-like, beaded markings but no true ribs; pseudoraphe present; no nodules.—Species many, fresh-water, marine and fossil.

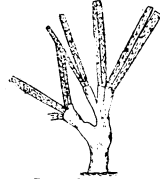
4. DIMEROGRAMMA

Cells united into ribbon-like chains, not cuneate, girdle view rectangular; valves lanceolate to linear-lanceolate, sometimes broader or narrower in the middle, not flat, raised at the ends, and

often in the middle, with coarse or fine transverse-punctate striations, interrupted by the pseudoraphe; with polar and often central nodules.—Species few, marine and fossil.

5. SYNEDRA

Cells free or attached, single or in fan-shaped clusters, not cuneate, girdle view linear; valves linear or lanceolate-linear, sometimes somewhat crinkled, transversely striate, mostly with a pseudoraphe; sometimes with false central and polar nodules.—Species many, fresh-water, marine and fossil.



51. *Synedra*; several cells, end and side, attached.

6. ASTERIONELLA

Cells attached into a star-shaped cluster, not cuneate, girdle view narrowly linear, with unequally thickened ends; valves narrowly linear with unequally swollen ends, very finely transverse striate, with a pseudoraphe; no nodules.—Species few, fresh-water and marine.

7. CERATONEIS

Cells free, single, not cuneate, girdle view linear; valves crescentic, faintly or not at all transversely striate; pseudoraphe present close to the concave edge; polar and central nodules present.—Species few, fresh-water and fossil.

8. EUNOTIA



52. *Eunotia*; end (upper) and side (lower).

Cells free or united into chains, or attached, not cuneate, girdle view rectangular-oblong; valves crescentic, often undulate on the convex margin, transverse striæ uninterrupted; pseudoraphe not evident; polar nodules present; central nodule wanting.—Species many, fresh-water and fossil.

9. TIBIELLA

Cells attached into fan-shaped colonies, cuneate in girdle view; valves curved, with the ends unequally swollen, finely transverse-punctate-striate, with marginal beads or spines; pseudoraphe indistinct; polar nodules present; central nodule wanting.—Species few, fresh-water and fossil.

FAMILY 19. NAVICULACEAE

Cells shorter than broad, rectangular in girdle view, mostly single, but sometimes connected in chains; rachis of valve containing a median elongated slit.

Key to the Genera

- I. Valves parallel,
 - a. Rachis of valves not keeled,
 1. Raphe almost straight,
 - (a) Raphe with a simple border,
 - (1) Septa of interzones (when present) not fenestrate,
 - †. Cells straight in girdle view.....1. *Navicula*.
 - ††. Cells curved,
 - §. Both valves with a raphe....2. *Rhoiconeis*.
 - §§. Only one valve with a raphe.....3. *Achnanthes*.
 - (2) Septa of interzones fenestrated,
 - †. Both valves with a raphe.....4. *Mastogloia*.
 - ††. Only one valve with a raphe,
 - §. Interzonal septa narrow, marginal, fenestrated.....5. *Cocconeis*.
 - §§. Interzonal septa complete, fenestrated.....6. *Campyloneis*.
 - (b) Raphe bordered by two ridges,
 - (1) Central nodule small or only slightly elongated.....7. *Brebissonia*.
 - (2) Central nodule much elongated, rib-like.....8. *Amphipecta*.
 2. Raphe strongly sigmoid or arcuate,
 - (a) Raphe sigmoid,
 - (1) Cell not twisted.....9. *Gyrosigma*.
 - (2) Cell twisted.....10. *Scoliopecta*.
 - (b) Raphe arcuate.....11. *Toxonidea*.
 - b. Rachis of valves with a keel,
 1. Keel (including the raphe) sigmoid, median..12. *Amphiprora*.
 2. Keel (including the raphe) arcuate, excentric..13. *Amphitrite*.
- II. Valves not parallel, ends approximating,
 - a. Cells straight in girdle view.....14. *Gomphonema*.
 - b. Cells curved in girdle view.....15. *Rhoicosphenia*.
- III. Valves not parallel, edges approximating,
 - a. Valves without transverse ribs,
 1. Girdle narrow, not striate.....16. *Cymbella*.
 2. Girdle broad, striate.....17. *Amphora*.
 - b. Valves with transverse ribs, raphe not evident....18. *Cystopleura*.

1. NAVICULA

Cells single, free or enclosed in gelatinous tubes, or rarely united in chains, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; with or without interzones, interzonal septa not marginally chambered; valves bilaterally symmetrical, with a straight raphe (or nearly so), no keel, and round polar and central nodules, the latter sometimes elongated (stauros); surface transversely punctate-striate or ribbed.—Species very many, fresh-water, marine and fossil.

53. *Navicula*; end view.54. *Achnanthes*; end view.55. *Cocconeis*; end view.

2. RHOICONEIS

Cells single, free, not cuneate, curved in girdle view, interzones several; valves elliptical-lanceolate, symmetrical, with a straight median raphe and central and terminal nodules; surface transversely striate.—Species few, fresh-water, marine and fossil.

3. ACHNANTHES

Cells single or forming short chains attached by the basal cell, cells curved only in girdle view; valves elliptical to lanceolate, often narrower or broader in the middle; valves dissimilar, the one concave with a true raphe and central and polar nodules, the other convex with a pseudoraphe, both striate with transverse rows of dots, sometimes ribbed.—Species many, fresh-water, marines and fossil.

4. MASTOGLOIA

Cells mostly enclosed in a gelatinous mass, not cuneate, lanceolate in valve view, and oblong in girdle view; valves like those of *Navicula*; two interzones present, each having a septum with a central opening surrounded by a row of rectangular chambers.—Species many, fresh-water and marine.

5. COCCONEIS

Cells single, free, straight or curved in girdle view, and the plane of the upper valve with its margins curved downwards;

valves round-elliptical to circular, dissimilar, the lower concave with a true raphe and nodules, the upper with a pseudoraphe and without nodules, both transversely punctate-striate; interzone one with a narrow marginal fenestrated septum, or none.—Species many, fresh-water, marine and fossil.

6. CAMPYLONEIS

Cells single, free, curved in girdle view, and the plane of the upper valve with the margins curved downwards; valves scutelliform, dissimilar, the lower concave, transversely punctate-striate, with a straight raphe and central nodules, the upper convex, cribose-punctate, with a pseudoraphe and without nodules; interzone one, between the lower valve and the girdle, its septum complete, fenestrated.—Species few, marine and fossil.

7. BREBISSONIA

Cells single, free or enclosed in gelatinous tubes, or sometimes stalked, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; without interzones; valves bilaterally symmetrical, with a straight raphe (or nearly so) which is enclosed between two parallel ridges; central nodule small, usually slightly elongated; surface transversely punctate-striate or ribbed.—Species few, fresh-water and marine.

8. AMPHIPLEURA

Cells single, free, or enclosed in gelatinous masses or tubes, not cuneate, narrowly lanceolate in valve view, narrowly oblong in girdle view; valves bilaterally symmetrical; raphe straight, bordered by two parallel ridges, and separated by the long, narrow, longitudinal, rib-like central nodule; polar nodules small; surface transversely striate.—Species many, fresh-water, marine, and fossil.

9. GYROSIGMA

Cells single, free or rarely enclosed in gelatinous tubes, not cuneate, straight and oblong-elliptical in girdle view, sigmoid in valve view; valves bilaterally symmetrical, sigmoid-lanceolate; raphe median, sigmoid; central nodule small; striations crossed obliquely (decussate) or at right angles (rectangular), reaching almost to the



56. *Gyrosigma*; end view.

raphe.—Species many, mostly marine, some in fresh waters, also fossil.

10. SCOLIOPLEURA

Cells single, free, twisted, not cuneate, girdle view oblong, the girdle oblique; valves elliptical, strongly convex, the raphe sigmoid, excentric; aentral nodule small; surface transversely striate, sometimes obliquely striate-pearled.—Species few, fresh water, marine, and fossil.

11. TOXONIDEA

Cells single, free, not cuneate, twisted, lunate or arcuate in valve view, the girdle oblique; valves unsymmetrical, with an arcuate excentric raphe, and central and polar nodules; striations decussate.—Species few, marine.

12. AMPHIPRORA

Cells single, free, not cuneate, twisted, lanceolate in valve view and oblong in girdle view but with a sigmoid girdle; interzones present; valves convex, with the raphe concealed in a sigmoid emarginate keel; central and polar nodules present; valves transversely striate, rarely scattered punctate.—Species few, fresh water and marine.

13. AMPHITRITE

Cells single, free, not cuneate, quite unsymmetrical; valves reniform, with an arcuate, emarginate, oblique keel at the convex margin including the raphe central and polar nodules present; interzones present; striations of valves transverse or irregular.—Species few, marine.

14. GOMPHONEMA

Cells single, mostly stalked or in gelatinous masses, cuneate in both girdle and valve views; interzones present; valves bilaterally symmetrical, often laterally twice indented; raphe straight, with central and polar nodules, the former sometimes transversely elongated (stauros); surface transversely punctate-striate.—Species many, fresh water, marine, and fossil.

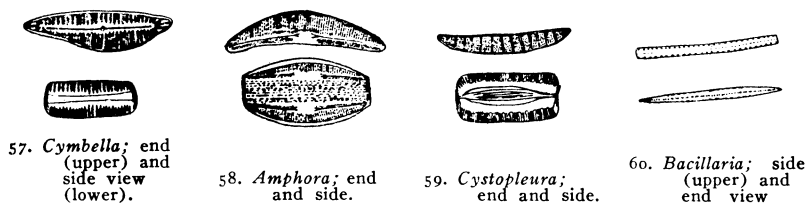
15. RHOICOSPHENIA

Cells mostly stalked, cuneate in both girdle and valve views, curved in girdle view; interzones present; valves straight, bilaterally

symmetrical, transversely striate, unlike; the concave valve with raphe and central and polar nodules, the other without nodules, and with a pseudoraphe.—Species few, fresh water and marine.

16. CYMBELLA

Cells single, stalked, (often becoming free) or enclosed in gelatinous tubes, oblong and straight in girdle view; no interzones; valves lunate, not symmetrical; raphe somewhat excentric, arcuate, rarely straight; central and polar nodules present; surface transversely striate, without ribs.—Species many, fresh and brackish waters, and fossil.



17. AMPHORA

Cells single, mostly free, elliptical to rectangular in girdle view; sometimes with cuneate interzones; valves lunate, not symmetrical; raphe excentric, near the concave margin, doubly arcuate; central nodule rounded or transversely elongated; surface transversely punctate-striate.—Species very many, fresh water, marine, and fossil.

18. CYSTOPLEURA

Cells single, rarely in short chains, attached ventrally to other plants, girdle view oblong to doliiform; interzones present or absent; valves lunate, internally transversely ribbed, transversely beaded externally; raphe excentric near the concave margin (by some considered to be a pseudoraphe).—Species many, fresh and brackish waters.

FAMILY 20. BACILLARIACEAE

Cells very short, mostly narrowly rectangular in girdle view, usually connected in loose chains or bands: rachis of valve containing a lateral, elongated slit.

Key to The Genera

- I. Keel median.....1. *Bacillaria*.
 II. Keel at one edge.....2. *Homoeocladia*.

1. BACCILLARIA

Cells parallel, in free chains, gliding upon one another in the chains, rod-shaped, straight, rhombic in cross section; valves linear, pointed, with a median, beaded keel in which is concealed the raphe transversely striate.—Species few, fresh water and marine.

2. HOMEOCLADIA

Cells mostly free, rarely in tubes or chains, sometimes stalked, elongated or linear, rarely cuneate, rhombic in cross section; valves linear to lanceolate, pointed, with the oblique, bordered keel at one edge enclosing the raphe; surface punctate or transversely or decussately striate.—Species many, fresh water, marine, and fossil.

FAMILY 21. SURIRELLACEAE

Cells very short, linear, cuneate, elliptical, ovate or nearly circular in valve view, more or less oblong in girdle view; rachis a median unmarked strip, with two lateral wing-keels each enclosing a slit.

Key to The Genera

- I. Valve surface undulate.....1. *Sphinctocystis*
 II. Valve surface not undulate,
 a. Valves cuneate, reniform, elliptical or linear.....2. *Surirella*
 b. Valves sub-circular, saddle-shaped.....3. *Campylodiscus*

1. SPHINCTOCYSTIS

Cells free, oblong to linear, straight; valve surface undulate and transversely striate, with a beaded keel on each margin, containing the raphe; along the center of the valve extends a straight pseudoraphe.—Species few, in fresh and brackish waters.

2. SURIRELLA

Cells free or stalked, straight or twisted, in valve view cuneate, reniform elliptical or linear, girdle view cuneate, elliptical oblong or sigmoid; valves with a beaded or ribbed keel on each margin containing the raphe; surface with ribs extending



(lower).
 61. *Surirella*; end
 and side, at-
 tached.

from the margin towards or to the median linear or lanceolate pseudoraphe.—Species many, fresh water and marine.

3. CAMPYLODISCUS

Cells solitary, free, disk-shaped, disk twisted or saddle-shaped, round elliptic; valves round elliptic, with short mostly radiate ribs, and a marginal keel concealing the raphe; pseudoraphe median, but at right angles in the two valves.—Species many, mostly marine, a few in fresh waters.



62. *Campylodiscus*;
end view.